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is only from such a foundation of well authenticated facts, that we can hope to deduce results of any importance. The investigators of America are now rapidly awakening to the importance of this work. Earnest observers are beginning thorough records in various portions of the United States. It has been my object to call the attention of the gentlemen of this Academy to the importance of organizing a series of careful records of the Ozonic phenomena of Kansas. To any one disposed to assist in this work I shall take pleasure in furnishing color scales, Iodized paper and record blanks, simply requesting that a copy of these be returned to me at the close of each month for tabulation.

The solution of this question is destined to become, from a chemical standpoint, one of the most important problems of the century before us; but a problem whose solution can only be purchased by long years of untiring study.

Kansas State Agricultural College, October, 1875.

THE NEBRASKA HOT BLUFF.

By Prof. Wm. K. Kedzie, of the Kansas State Agricultural College.

The somewhat startling natural phenomenon to which it is the object of this paper to call attention, is a bluff of the Missouri river, on the northern boundary of Nebraska, and near the village of Ionia. It is also not very far distant from the opposite town of Yankton, Dakota, and has been principally visited and described by prospectors from our latter city.

It is in appearance a quite ordinary river bluff, about a thousand feet in length, one hundred and fifty feet high, and sloping from the river by which its base is washed at an angle of 70 or 75 degrees. By the undermining action of the river a large mass, some five hundred feet long, one hundred feet high, and twenty to thirty feet thick, was some months ago scaled from the face of the bluff and fell to its base, forming a large mass of debris rising at some points fully forty feet above the level of the river. It is this immense fragmental mass which has displayed the striking phenomena so terrifying to the ignorant and superstitious of the neighborhood, and which very beautifully illustrates the important chemical transformations constantly in progress within the earth's crust.

Attention was first called to the peculiarities of this locality by a party of miners who were prospecting for indications of coal veins. On passing over this mass of debris, they found steam escaping from the crevices at every point. The ground was also perceptibly heated, and by placing the ear to the earth a crackling sound was heard proceeding from below. An opening was made in the mass to the depth of two feet, when the heat became so intense as to be scarcely endurable. Upon perforating the heap still further with an ordinary augur, the temperature was found to be rapidly increasing with the descent. An ordinary thermometer with a range of one hundred and fifty degrees was thrust into the augur-hole thus made, when the mercury shot up so rapidly to the top of the tube that it had to be instantly withdrawn to prevent the bursting of the bulb. All these circumstances carefully considered seem to indicate that the temperature of the interior of the mass was fully 212° F. The exterior was, as a rule, coated with a hard incrustation of mineral salts brought up by capillary action from below; on breaking this the interior was found in a fine pulverulent

condition, closely resembling the slaking process of lime. The intense heat of the mass made itself felt for many square rods around, and the steam escaping from the crevices was of a peculiarly sour, pungent odor. The mass is completely impenetrated by an abundance of beautiful crystals of Selenite (Gypsum); many of the crystals microscopic, others aggregated into masses of considerable size, and others still most perfectly rhomboidal crystals upwards of a pound in weight. Peculiar incrustations are also noticed on the face of the partially decomposed rock, in some cases in the form of a white flaky powder, having the taste of common alum; in others in the form of efflorescent crystals giving the marked flavor of Epsom salts. As already intimated the superstitious denizens of this region at once leaped to the conclusion that a young volcano had burst upon them in all its fury, and fortified themselves with due courage to meet the emergency. Attracted by their somewhat exaggerated accounts, Mr. A. W. Barber, the editor of the Yankton Press, visited the locality and made a careful and intelligent examination. It is to his courtesy that I am indebted for an interesting box of specimens of the minerals here undergoing such vigorous transformations, and for a full account of the nature of the bluff. A chemical examination of these specimens reveals at once the nature of the interesting transformations here in progress, which, while known to be actively in operation in many localities in Europe, have as yet been observed at comparatively few points within the limits of the United States.

This so called "hot bluff," then, consists of two separate and mineralogically distinct ingredients. The main portion of the bluff from the base up to the height of a hundred feet consists of a bluish gray rock of uniform texture, somewhat schistose, soft and easily yielding to the knife, and to the eroding action of the river. So evenly balanced are its constituents that it seems a matter of question whether it should be properly called an argillaceous limestone, or a calcareous slate or argillite. For while upon analysis it is found to contain but about twenty per cent. of the earthy carbonates of calcium and magnesium, it yet offers all the characters of a magnesio argillaceous limestone, effervescing but slowly in cold acids, but with quite violent action upon elevation of the temperature.

Next above this the upper and remaining fifty feet of the bluff is completely interwoven with seams of varying thickness of a soft, friable, blue-black shale, in which exist in great quantity microscopic crystals of the bisulphide of iron (Fe S_2), commonly known as iron pyrites. Nuggets of the same mineral are also found abundantly distributed over the face of the bluff. Now it is the products of the decomposition of this iron pyrites which form the active agents of all the violent chemical reactions here observed. We know that when exposed to the influence of atmospheric oxygen and moisture this mineral is rapidly decomposed, absorbing oxygen and becoming converted into Ferrous Sulphate, (Fe SO_4), commonly known as green vitrol, and free sulphuric acid. Represented by formulae, this change would be: $\text{Fe S}_2 + \text{H}_2\text{O} + 7\text{O} = \text{Fe SO}_4 + \text{H}_2\text{SO}_4$. This Ferrous Sulphate again on more extended exposure is still further oxidized and becomes Ferric Sulphate or Sesqui-Sulphate of Iron ($\text{Fe}_2\text{S O}_4$). This in its turn is a very unstable compound, and when brought in contact with other bases readily yields up its sulphuric acid and becomes converted into the hydrated oxide of iron. When exposed in considerable mass, this decomposition of iron pyrites of course proceeds but slowly, and specimens are frequently found illustrating the change in all its gradations. But when, as in the soft shale of this Nebraska bluff, it is found in the form of fine crystals appearing as glistening specks to the naked eye, its decomposition is very rapid and an

abundance of free sulphuric acid is produced. Hence it will hardly be a matter of surprise when I state that the soft shale from the upper layers of this bluff has become so charged with free sulphuric acid as to be strongly sour to the taste and acid in reaction. In fact, on allowing a specimen of this shale to remain undisturbed in my laboratory for several months it was found to afford 5.35 per cent. of sulphuric acid in the form of the freely soluble sulphates of iron and aluminum.

Thus we have in the chemical constitution of this hot bluff a perfect explanation of the startling phenomena which are there occurring. Below, a rock largely consisting of earthy carbonates freely decomposable by the presence of free acids. Above, a series of layers completely charged with an abundance of this free acid. When, by the scaling off of the face of the bluff, these agents are intimately mixed in an immense mass of thousands of tons of debris the free acid immediately attacks the easily yielding carbonates with great violence, and a "hot bluff" very naturally springs at once into existence. The intense degree of heat produced, however, is from another and more complex cause than this. If the simple acid shale were by itself without the limestone, piled in a large heap, and water added, there would be a very rapid rise of temperature within from the greatly increased rapidity with which the process of the oxidation of the iron pyrites would go on under these circumstances. It is well known that in the shales of Whitby, England, when thus piled and moistened with water, the oxidation of the pyrites will develop so intense a degree of heat as to spontaneously set fire to the bituminous matter which the shale contains. But when, as in the case of this Nebraska bluff, to the heat generated by this rapid oxidation produced by increased exposure to air and the water of the river and rains, there is added the violent avidity with which the free sulphuric acid attacks the carbonates of lime and magnesium, the effect is naturally powerful and startling in the extreme.

Under these encouraging conditions many interesting chemical compounds are here in the process of formation. By the decomposition of the carbonate of calcium by the sulphuric acid, magnificent crystals of Selenite (Gypsum), are now forming in immense abundance. The crystals are exceedingly perfect and beautiful; many of them somewhat rare in form, long, slender, needle-shaped crystals, but still perfect rhomboidal prisms with bevelled edges. In some instances in the solid mass of the bluff itself, where the layers of the limestone and the acidified shale are conjoined, there are formed seams of a half inch or more in thickness completely filled with interradiating crystals of Selenite partially coated with the yellow hydrated oxide of iron. By the decomposition of the magnesium carbonate there is here formed magnesium sulphate or Epsom salts distributed over the rock in a very minute incrustation of efflorescent crystals.

Finally, by the slow decomposition of the argillaceous or clayey portions of the rock itself there is produced the Sulphate of Aluminum in minute crystalline tufts called on account of its form "Feather Alum." These last two compounds suggest an economical phase of what has thus far been simply an exceedingly interesting chemical phenomenon. It is well known that the great proportion of the common alums are manufactured from shales almost identical in nature with those which form the black seams of this Nebraska bluff. In the great English alum fields, for example, the shale, full of partially decomposed pyrites, is collected, piled in oblong heaps, and slowly fired to completely carry out the oxidation which has been begun. A large quantity of free sulphuric acid is thus produced which attacks the shale forming Aluminum Sulphate. This is removed by leaching

with water and the addition of some available form of potash or ammonia is all that is needed to crystallize out the common potash or ammonia alums of commerce. Now, in the case of this Nebraska bluff, this oblong mass of heated debris bears no very distant resemblance to a "curing heap" of an alum manufacturer. The presence of the limestone is, to be sure, most unfortunate, and would necessarily be avoided if the acidified shale was to be handled with a view to profit. The small quantity of the magnesium carbonate present would be by no means unpropitious, as the manufacture of Epsom salts and the alums is frequently carried on together at a handsome profit. If the accounts of intelligent observers are to be accepted, there would seem to be little doubt that this region may prove available in these branches of manufacture. But whether thus utilized or not, this display is surely a most fascinating one to the chemist and mineralogist—nature seeming, in some degree, to have pulled aside the curtain and given us a peep behind the scenes, where we are permitted to see her in the very act of forging these marvels of crystalline creation.

KANSAS CHALK.

By G. E. Patrick, Professor of Chemistry and Physics, Kansas University.

The existence of chalk in North America is a comparatively new fact in science. Prof. Dana, in his *Manual of Geology*, (editions previous to the last, 1874,) says, in speaking of the Cretaceous beds of this country, "they include in North America no chalk." Within the last few years, however, it has become generally known to the scientific men of Kansas, that there occur, in the Cretaceous formation of this State, vast beds of what must be considered a true chalk. Specimens of this have been sent to Prof. Dana for examination, with the result that in the last edition of his *Manual*, (1874,) he corrects the statement above quoted, and acknowledges the existence of chalk in the Cretaceous of Kansas.

The beds are of great extent, so great that in case a demand for it should ever arise, the supply would be practically limitless. They are in the western part of the State, from three hundred to three hundred and twenty miles west of Kansas City, and within three miles of the Kansas Pacific Railroad.

The chalk is, as a rule, very soft and fine grained, though in this respect it varies with the amount of impurities. The color of many specimens I have seen, is a snowy white; but a large portion of it is slightly tinged with yellow, by oxide of iron.

Examined under the microscope, it appears perfectly amorphous—a simple aggregation of shapeless particles. The Rhizopod shells, which almost universally occur in the chalk of the Old World, sometimes comprising nearly its entire substance, seem to be quite wanting in our Kansas chalk. With a good microscope, and a high power, I have been unable to detect any trace of them.

To believe that these shells were originally in the chalk, during its formation and subsidence, and that by water action they have become so completely disintegrated as not to leave a trace, involves too great an assumption; hence it is my opinion that our chalk was not formed, like that of England and France, by the aggregation of myriads of Rhizopod skeletons—